Report on The First Meeting of

The Lifelong Learning Network

Organized by RIKEN Brain Science Institute
(BSI /RIKEN)
The OECD Center For Educational Research and Innovation
(OECD/CERI)
With The Support Of
The Japanese Ministry of Education, Culture,
Sport, Science And Technology
(MEXT)

Yokohama Royal Park Hotel
Japan

December 10-11, 2002

INTRODUCTION

A first meeting of lifelong learning network (LLLN) members, organized by the RIKEN Brain Science Institute (BSI), Japan, as part of a larger OECD-CERI project, designed to link educational policy making with basic neuroscience, was held on December 11th and 12th in Yokohama, and attended by 50 participants including members of the network, OECD delegates, representatives of the Japanese government, educators, brain scientists and journalists.

The programme was divided into three sessions (learning in infancy, learning in childhood and learning across life, with a science and education dialogue attached to each) followed by a strategy meeting. The dialogues were intended to discover common ground between basic neuroscientists and educators, with a view to forming a strategic platform upon which to formulate and build educational policy. The strategy meeting itself, on December 11th, was designed to draw together arguments from the preceding three dialogues into a set of concrete proposals for action. A short business meeting was also held before the strategy meeting to inform network members of funding arrangements for the network.

In the strategy meeting the wide-ranging discussion of sessions I-III was reduced to five core activities under the heading “creating a new field”:

1 Clarification of complexity,
2 Dissemination of information,
3 Research collaboration,
4 The development and ethical supervision of novel research,
5 Management of 1) to 4) above, with commitment to a second meeting in December 2003 or January 2004.

As a means of defining the boundaries of a new field of brain science relevant to lifelong learning and the development of educational methods and policies within those boundaries, the five activities plan was welcomed by the meeting. Given the time constraints, however, attention focused on activities 1) to 3). With regard to 2) the meeting was advised by Bruno della Chiesa (OECD/CERI) and Emile Servan-Schreiber (consultant to the OECD) of plans for an OECD managed website to serve all areas of the project, including the LLLN. The idea of a science writer or number of science writers to facilitate communication of research findings to a wider audience was also welcomed by the meeting.

It was further decided that the next meeting will again be in Japan and that educators will lead it with scientists participating in the dialogue sessions.

This report was prepared by Dr. Michael Miller (Senior Adviser, BSI) with the assistance of Bonnie Lee La Madeleine and requests for further details and enquiries should be sent to:
michael-miller@brain.riken.go.jp

[Editorial comments and explanations in the text are enclosed in square brackets.]

Brain Science Institute (RIKEN)
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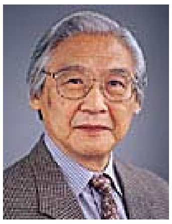
SUMMARIES OF THE THREE SESSIONS

The presenters' own synopses of research are provided as abstracts at the beginning of each session summary, followed by questions and answers. The science and education dialogue is then used to draw connections between authors' findings and comments from the audience for the whole session. In this way we present an overall view of the meeting, as intended to establish a network of educators, education policy makers and neuroscientists; rather than a detailed commentary on the research presented. A summary of opening remarks from three speakers, representing BSI (RIKEN), OECD/CERI and MEXT, is also presented.

Masao Ito (BSI, Japan), Bernard Hugonnier (OECD/CERI, France) and Masayuki Inoue (MEXT, Japan)

Opening remarks



Masao Ito, as Director of BSI, opened the meeting and introduced its central purpose of creating "collaboration between learning sciences and brain research on the one hand, and researchers and policy-makers on the other . . ..”[1].

The aim was to establish how the mind grows to establish a conscious self. And because it retained a great deal of plasticity, we could continue to learn throughout life. The network aimed to find answers to three questions:

1. How does environment influence early brain development in terms of neural structures, sensory functions and behavior?
2. How do children grow in terms of speech, sensory motor functions, emotion, learning of art and music and frontal cortical functions?
3. How can we maintain learning in aged people, restore lost function in age-damaged brains and live well in an information based society?

To answer these three questions the network addressed learning issues in infancy and childhood, and neurocognitive decline in older adults.

In the present meeting there were three sessions. Each followed by a science and education dialogue offering an opportunity for discussion. And on the second and final day (December 11th) a strategy meeting would be held to discuss how the network might grow and develop.

1 Preliminary synthesis . . . first high level forum on learning sciences and brain research", New York: Sackler Institute, 16-17 June 2000, 3.

Bernard Hugonnier (left), OECD emphasized Masao Ito's statement of central purpose, and described it as being to "build a community of interest". The OECD was a forum of 30 member countries, with a further 40 nations involved, and its purpose was to share experience and improve economic policy.

The Centre for Educational Research and Innovation (CERI) was newly created. The directorate had been set up only three months before, and it had seven major objectives:

1 To re-think the nature and uses of human capital.
2 To have a vision of education in the future.
3 To ask how to manage the increasing volume of knowledge and to understand its role in society.
4 To better understand the internationalization of educational services.
5 To recognize special educational needs, such as learning and physical disabilities, and to work to incorporate these needs into education. As part of this it was also necessary to understand the roles of public and private education.
6 To encourage innovation in education.
7 To apply brain research to educational theory and practice.

There were three basic reasons for looking at these issues:

1 Research suggested that one out of six children hated school,
2 Citizens as consumers of education were not satisfied with the services on offer.
3 We were not properly exploiting children's own learning abilities. We were not encouraging them to use their own brains. On the PISA[2] scale, for example, significant numbers of children in the industrialized countries were not, in terms of education, adequately prepared for working life.

Attrition in the teaching profession was very high. Eleven per cent of teachers changed jobs within a year and 39% within five years. Teachers in England, when surveyed, cited poor pupil behaviour and excess work as the main reasons for leaving the profession. It was obviously necessary to make teaching more attractive as a profession. And better understanding of how the brain worked would make teaching more effective. Bernard Hugonnier then summarized the various social and individual factors at work [Figure 1] and asked how educators could bridge the gap between the two sorts of economy within the four parameters of: fewer welfare resources, more individualist patterns of consumption, increasing social responsibility and a society . . . increasingly information driven.

2 Programme for International Student Assessment: survey of the knowledge and skills of 15 year olds in the principal industrialized countries. See www.pisa.oecd.org.

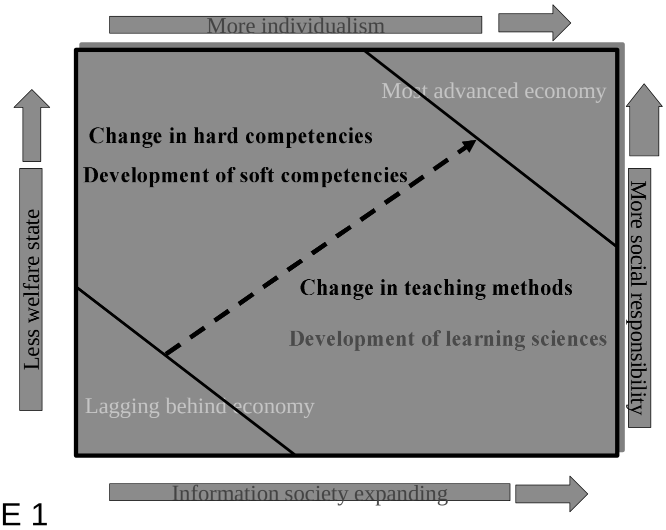


FIGURE 1

The aim in making such a bridge was, on the demand side, to encourage students to learn more and to be more independent learners. And on the supply side, to improve the quality of teaching. Thus improving the utilization of human capital.

The interests of the following speaker, **Masayuki Inoue**, as Senior Deputy General of MEXT, were more local; reflecting the concerns of a policy maker with pressing issues in both science research and education design. Mr. Inoue declared that he had prepared a speech but, having heard the other two speakers, he was going to present his thoughts extemporaneously. He listed words associated with creativity – that he had read in the Nobel Museum: "meeting, communication, contact, chaos, networking, slump, vision, disrespect and diversity". He then drew attention to educational problems in Japan including the collapse of classroom discipline, learning disability, truancy, lack of incentive and language learning difficulties. Furthermore he thought that while opening minds was the goal of education, administrators also needed to learn to answer problems, have better access to resources and a better feedback system.

As to his own ministry: MEXT had a four year plan (2001-5) for the strategic support of four areas: life science, the environment, nanotechnology and the material sciences. But his own personal interest was in language learning around the ages of 10-12, and he hoped to discover more about this in the meeting.

Session I: learning in infancy

Janet F. Werker (left) with Athena Vouloumanos (University of British Columbia, Canada)

Bootstrapping from speech into language: neural and behavioural foundations.

In 1984, we provided the first evidence revealing a change in speech perception in the first year of life from language-general to language-specific phonetic perception (Werker & Tees, 1984). This reconciled previous findings showing language-general categorical perception by young infants but restricted discrimination by adults to only native language phonetic contrasts. Following this initial work, there has been an explosion of research showing that over the first year of life infants tune into many other properties of the native language from phonetic segments to stress patterns to acoustic and phonological cues to grammatical class. Indeed, the basic question of how infants even get started in listening to speech as "speech" has been readdressed. More recently, there has been a specific emphasis on how the changing speech perception sensitivities contribute to language use, the learning mechanisms involved in these changes, and the underlying neural processes involved. This talk will provide a broad overview of this work, with a focus on recent behavioural and neuroimaging work from our laboratory that has contributed to our understanding of the new directions.

Dr. Marie Cheour, the first questioner, asked if Dr. Werker had compared natural with synthesized language. She replied that she had not. She had used a sine wave comparison. But the question was an interesting one and she could report anecdotal evidence of working with Hindi and natural language, that the attrition rate for synthetic language was higher. Dr. Cheour then asked if the brain's preference for speech was based upon its recognition of speech as speech or upon familiarity. The answer lay, Dr. Werker thought, in a further study with infants using a non-native language rather than their own language.

Dr. Tanaka said that his understanding of Dr. Werker's presentation was that the language learning process was not the general shaping of the whole perceptual system, but the creation of a new organization. So base capability remained. This seemed similar to him to specialization in visual object recognition. Bird watchers, for example, possessed extraordinary visual ability. He wanted to ask, therefore, if the skills remained at a perceptual level. Was there no deterioration in adult perception? Dr. Werker replied that she had debated long and hard with herself whether to include data that indicated there was no loss between infant and adult. And flexibility did remain. It was possible to teach adults to improve their performance in hearing non-native sounds using suitable cues. But the full capacity did not remain even at a perceptual level.

The final question again concerned flexibility in language learning ability into adulthood. While some perceptual abilities remain, Dr. Werker thought, the full system did not; but again, the area required further, careful study.

Some adopted Korean war orphans (4-6 years) have been able to learn two languages (English and French) without apparent interference from Korean.

Even bi-linguals from birth tended, some researchers had found, to show a neural and behavioural preference for one language; if a gating task were used to explore the matter. On the other hand, research also showed that some adopted Korean war orphans (4-6 years) were able to learn two languages (English and French) without apparent interference from Korean. But the whole area of study needed re-visiting using the new behavioural and imaging techniques now available.

Risto Nätäänen (left) and Marie Cheour (University of Helsinki, Finland)

Speech-sound learning in infants

During early childhood, language-specific memory traces for native-language speech sounds are formed in the infant's cortex. This neuro-developmental process serves to increase sensitivity to contrasts present in the child's native language. The fastest native and non-native speech-sound contrast learning is likely to take place when the child still is in the process of building the native-language memory traces serving as recognition patterns in speech perception. This hypothesis is supported by our recent results showing that in young children, such memory traces for foreign phonemes develop in less than two months, whereas this takes considerably longer in adults. In future, we will investigate the neurobiological manifestations of native- and non-native speech-sound discrimination in infants. We will train infants to discriminate native- and non-native phonemes in order to test our hypothesis, according to which non-native speech-sound recognition patterns, developed via this training, will permit quicker and more accurate foreign speech-sound discrimination and perhaps improved pronunciation later on, as compared with children not receiving this training. Up to date, sleep has been viewed as a sedentary state whereby capacities such as attention and learning are markedly reduced, or indeed altogether absent. Moreover, many scientists have long believed that infant long-term memory is quite immature. Our recent results demonstrate, however, that human newborns can learn to discriminate difficult speech-sound contrasts in a couple of hours while they are sleeping. In future, we plan to investigate infant memory and especially *learning during sleep.*

A key concept of the research presented was that of "mismatched negativity" (MMN) and Bruno della Chiesa asked for the term to be defined again: MMN was a response obtained from magneto-encephalography or electro-encephalography. It is a sign of sense detection in the auditory cortex and has a secondary activator in the frontal areas of the brain. MMN is used in the present research for language acquisition, but as a technique it might also be used for discrimination of musical sounds, for example.

Dr. Uylings then asked about the importance of sleep in learning for children and if it was as important as for adults: Dr. Cheour replied that she had not studied MMN during sleep, but changes in MMN amplitude had been detected in sleeping adults.

A third question concerned rapid eye movement (REM) and non REM sleep: infants had an estimated 50% of REM sleep and differences between the types of sleep had been related to plasticity and learning: what did Dr. Cheour make of this? She agreed that she would expect to see a significant difference between the two types, but defining changes of sleep rhythm, online, in an experimental situation was very challenging in infants. But such research could and should be done. Dr. Nätäänen added that in other work carried out in their laboratory researchers had found that replay of learned aspects occurred not during REM sleep, but other phases of sleep. Furthermore, what they saw in learning - replay of activity during sleep in the hippocampus and accumbens, for example - was present not during REM sleep but in other phases.

The chances of helping children are better because of their brain plasticity. Also children could be given special help around infancy so that they could fit into regular classes later.

Another question concerned language and the extent to which education might "change the situation at birth". Dr. Cheour thought the chances of helping children were better because of their brain plasticity. Also children could be given special help around infancy so that they could fit into regular classes later. She also observed that in discussing impairment in dyslexic children, one was not discussing a homogenous group, but children with very different problems. [The International Dyslexia Association, www.interdys.org, defines "dyslexia as follows: "a specific language-based disorder of constitutional origin characterized by difficulties in single word decoding, usually reflecting insufficient phonological processing abilities. . . Dyslexia is manifest by variable difficulty with different forms of language, often including, in addition to problems reading, a conspicuous problem with acquiring proficiency in writing and spelling." The Association also defines dyscalculia: "a mathematical disability in which a person has unusual difficulty solving arithmetic problems and grasping math concepts". The difficulties of defining both of these disabilities and devising educational strategies to deal with them were part of the discussions at the OECD/CERI meeting in Boston in January 2003.] The advantage of MMN was that it might be used to indicate the kind of problem a child had and therefore guide the help given.

Finally, Dr. Cheour was asked if there were evidence in infants that MMN was coming from the frontal areas as well as the auditory cortex. She replied that there was no clear localization possible, but comparison of a component following MMN might indicate frontal involvement. Distinction was easier, however, with infants when using EEG and she was optimistic that further research, using a refined helmet would yield clearer results.

Frances Champagne for Michael J. Meaney (left), McGill University, Canada)
Maternal care, gene expression and brain development: evidence for intergenerational effects.

Maternal care alters the development of emotional and endocrine responses to stress in the rat through changes in the expression of genes in brain regions that mediate stress reactivity. Most notable are the effects on systems that regulate CRF expression in hypothalamus and amygdala. Adult offspring of mothers that exhibit increased pup licking/grooming and arched-back nursing (LG-ABN) show increased hippocampal glucocorticoid receptor mRNA, as well as increased GABAA/BZ receptor binding in the amygdala and locus coeruleus that correspond to altered a1 and g2 receptor subunit expression, and are accompanied by changes in GAD mRNA levels in the medial prefrontal cortex, suggesting increased GABAergic activity at multiple levels. The variations in maternal care derive from differences in estrogen-induced oxytocin receptor levels in brain regions that regulate maternal behavior. Moreover, environmental stressors produce patterns of maternal care that promote increased stress reactivity (ie, Low LG-ABN care). These findings suggest that maternal care acts to program stress reactivity in the offspring through effects on systems that regulate CRF activity. The results of adoption studies suggest that these effects are indeed directly related to variations in maternal care and form the basis for a non-genomic transmission of emotionality across generations.

Dr. Werker asked about the effects of housing in the rat models described: did housing fully reverse earlier experience in rats of such experiences? And are the effects evident throughout the nervous system for gene expression or are the effects limited? The speaker replied that for the oxytocin system, for example, there was complete reversal. [The hormone, oxytocin, is released from the posterior lobe of the pituitary gland: it stimulates contraction of uterine smooth muscle during labor, lactation and is involved in establishment of maternal behaviour] Downstream there may be different factors leading to the observed effects. For behavioral matters, at least they had seen complete reversal of the phenotype. A related question concerned enrichment /impoverishment of environment. Were they made in terms of opportunities for social interaction or exploration? Social interaction was very important for rats and it could be argued that this alone might be a determining factor for enrichment or impoverishment. But with impoverishment the experimental rats certainly had very little room to explore.

Dr. Hensch asked if the speaker had performed similar experiments using mice – particularly knock-out mice. Did she think the fostered, offspring of knock-out mice that were poor mothers, would also turn out to be poor mothers? Dr. Champagne answered that they had not looked at such a mouse model.

Drug abuse and the effects of methamphetamine and cocaine on behaviour formed the basis of the next question. Such experiments were now underway, and the reward system in such animals may be very different.

How did these experiments with rats translate to humans? Licking and grooming in rats provided tactile stimulation leading to increased hippocampal synaptogenesis, and some research with premature babies suggested contact and handling were important to better health outcome, but it was hard to make any direct correlation.

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There was some evidence that an ineffective mother may be compensated for by an effective father and possibly peer groups may, to some extent, compensate. Was it possible to examine such evidence with rat models? Dr. Champagne replied that this was not possible with rats because mothers carried out the parenting. The males would only stress the mothers if they were housed with them. But they were now extending research to a bi-parenting model.

Takao K. Hensch (left) , BSI, Japan
Critical period mechanisms for brain development.

Neuronal circuits in the brain of young animals exhibit remarkable flexibility to reorganize in response to changing sensory experience. However, this ability is gradually lost as they grow older. We have identified a mechanism in the cerebral cortex that establishes a “critical period” for plasticity. Occluding one eye during a brief time in early life can permanently rewire the visual system in favor of the stronger input. We discovered that sensitivity first appears when particular GABAergic connections within neocortex mature. Our work will pursue the specific interneuronal subtypes as well as cellular and molecular events downstream of this inhibitory trigger that eventually terminate the critical period.

Neuronal circuits in the brain of young animals exhibit remarkable flexibility to reorganize in response to changing sensory experience. However, this ability is gradually lost as they grow older

The first questioner asked if it were possible to manipulate not only onset but duration of the critical period. Dr. Hensch replied that it should become possible, but their results suggested that if it were triggered early it then ended early, so the inhibition sets off a cascade of events that runs through in a finite time. Furthermore, looking at this critical period across species, the duration of the period correlated well with the expected life span of the species. In a mouse it was two weeks, in a human, it was believed to be several years. So if we were able, in some way, to delay the "hard wiring" of connections, it might be possible to delay the critical period.

The second questioner wondered if it were possible to make a general assumption about critical periods, their flexibility and management – he had in mind critical changes involving sexual hormones, for example. Dr. Hensch replied that a topic that might come up in the strategy meeting planned for the next day was terminology: the term "critical period" was used in many ways and many critical periods probably had different cellular mechanisms. He added that he had translated excitatory and inhibitory into glutamate and GABA, but GABA – early in development - is depolarizing or excitatory. So perhaps some other receptor system may play the inhibitory role. He had wanted to convey the principle and there was a need to look at other molecular players.

Werner Lenz (left) University of Graz, Germany, and Bruno della Chiesa, OECD/CERI, France:
moderators
Science and education dialogue.

Bruno della Chiesa began the dialogue by announcing that Dr. Gabrieli's talk on "Development of cognitive control and emotion regulation in children" would not take place in the afternoon because Dr. Gabrieli had been unable to join the meeting. He then went on to say that the OECD project had, so far, had three fora: the first in New York demonstrated that such dialogue was both necessary and possible, the second in Granada had shown it could be very difficult, and the third in Japan demonstrated it could be fruitful. So he hoped that the present meeting would be just as fruitful. He then went on to ask Jarl Bengtsson to speak. Jarl Bengtsson had taken the initiative at OECD in setting up the project.

A challenge for educationalists/ policy makers - is to take a less skeptical view of brain research

Jarl Bengtsson said that since the meeting was already overlong he would make just four points:

1 A science and education dialogue was something very important – as seen from the OECD perspective.

2 If one looked at science and education from a historical perspective, there had been a very weak connection or debate between them. It has been dominated by norms and values and education.

3 Such a situation was now more difficult to defend when education was such a priority for all governments. All OECD countries were certainly involved. Education – a huge enterprise – some 6% of GDP – must have a stronger science base. In order to build up such a base there needed to be a dialogue between stakeholders: between researchers, policy makers and practitioners.

4 In building such a dialogue, there were challenges for both communities: researchers and education policy makers and practitioners. There were at least three challenges for each of them: educationalists must support much more the new learning of brain sciences, there was also a need for more government support – and it would most likely pay off. Secondly educationalists must get into an intensive debate with the scientific community. It was not only money – educationalists must understand what was happening and that could only be achieved through dialogue. A third challenge for educationalists – at least the policy makers - was to take a less skeptical view of brain research. At present they saw it as both risky and elite. There was a challenge to the education community to take a more balanced view. As to researchers: there were at least three challenges. The first was: go for it! Go for a couple of Nobel prizes on brain and learning in ten years time. Secondly, be more transdisciplinary. Thirdly be open, be daring, take risks. And communicate much more: communicate with a broader audience.

Werner Lenz, as the second moderator of the discussion, posed four questions for the researchers of session I:

1 He pointed out to Dr. Hensch that the term “critical period” in education did not mean the same thing as the process described by Dr. Hensch, and asked him how his use of the term had a bearing on education.

2 He asked Dr. Champagne how important tactile stimulation was to learning and education.

3 He asked Dr. Cheour what could be expected educationally from her research.

4 He asked Dr. Nätäänen if the MMN data were useful to improvement of reading ability and language learning.

END OF SESSION I

Session II: learning in childhood

Harry B. M. Uylings (Netherlands Institute for Brain Research)

Phases in development and aging of the human cerebral cortex: genetic influences on human cognitive abilities.

Major neuronal outgrowth takes place in the first 2 postnatal years. The mature level is reached at an age that the mature brain weight is reached, i.e. about 3-4 years. A differential pattern in volume increase has been detected, however, for particular cortical areas. Neurochemical/transmitter development runs further into puberty until about 15 years, such as the cognitive development. Brain volume in young adults and intelligence is largely genetically determined.

The present outlook on age-related changes in adulthood is less grim. They appear to be specific to brain region and cortical layer rather than a general feature of the whole brain. Especially the association cortices are affected and the primary visual and somatosensory cortices are relatively spared. Our research for genetic-environmental influences on development and on combining microscopical anatomy with macroscopical imaging of living persons is indicated. The last subproject is a collaboration with Prof. Zilles' group and is essential given the huge interindividual variation in human brain structure and function.

The short answer to the question on how to make life more productive intellectually for older people is to stay physically and mentally active

The first question (Emile Servan-Schreiber) following Dr. Uyling's presentation concerned developmental maturity. When was the brain completely finished? Dr. Uyling's replied that the brain never finished changing, but structurally it was complete with regard to size about the age of five. With neurotransmitter networks being developed as late as 18-20 years of age. But axonal refinement never finished.

Dr. Laukkanen then asked what Dr. Uylings had meant by intelligence. And in asking the question he was thinking of Howard Gardner and the multiple intelligence theory [Gardner proposed the existence of at least seven intellectual areas: linguistic, musical, logico-mathematical, spatial-kinaesthetic, interpersonal and intrapersonal]. Dr. Uylings replied that he was using the term "intelligence" not in any precise way; there was a number of types of intelligence, perhaps seven or eight. They were trying to make a distinction in their research between them and would examine the matter in the coming years.

Dr. Werker then asked how it was possible to tie brain research into behavioural work with regard to structure. It was a challenge for the group to determine which measures of brain development might be related to behaviours. Dr. Uylings replied that during development there was a lot of opposition between fiber systems. There was, for example, a reported decline in the number of synapses in the visual cortex between four and ten years of age. Specification of the different fiber systems for this and other areas would be interesting when correlated with behavioural studies. How is optimal specification managed for a particular system and a particular person? How flexible is the optimum?

Denis Ralph then introduced himself as an educational policy maker and asked what advice Dr. Uylings could offer about making life more productive intellectually for older people. The short answer, Dr. Uylings replied, was to stay physically and mentally active. But tomorrow the meeting would go into more detail on the topic.

Kikuro Fukushima (Hokkaido U., Japan)

Role of the frontal cortex in smooth tracking eye movements in three-dimensional space.

With development of a high acuity fovea, frontal eyed-primates acquire the ability to use binocular eye movements to track small objects moving in space. The smooth-pursuit system moves both eyes in the same direction to track targets moving in the frontal plane (frontal pursuit), whereas the vergence system moves left and right eyes in opposite directions to track targets moving towards or away from the observer (vergence tracking). At cerebral cortical and brainstem levels, signals related to vergence eye movements and the retinal disparity and blur signals that elicit them, have been found to be coded independently of signals related to frontal pursuit. Our recent studies in trained monkeys show that these signals are represented in an entirely different way in the smooth-pursuit region of the frontal eye fields (FEF). FEF pursuit neurons modulate strongly during both frontal pursuit and vergence tracking, resulting in three-dimensional Cartesian representation of eye movements.

Smooth tracking of small objects moving in space also requires maintenance of the target image on the fovea by compensating for the long delays involved in processing visual information and/or eye movement commands. Our results also present evidence that FEF pursuit neurons carry predictive signals for smooth ocular tracking.

Dr. Tanaka asked if Dr. Fukushima had been able to demonstrate symmetry in human infants. Dr. Fukushima replied that he had not. That the youngest age tested was six, the published data was for ages 8-11, and even in 11 year old children it was problematic [in his presentation Dr. Fukushima described how vertical smooth-tracking – with respect to a possible model of visual development in children (ages 10-12) - occurred “late”. He was interested in establishing what part of the brain was involved in such maturation and how it occurred].

Dr. Ito asked if the experimental method might be applied to adults whose prefrontal areas were not mature. Dr. Fukushima thought this possible because the method was simple and yielded objective data.

Dr. Tanaka: "So cerebellar control is not complete and there is compensation." Dr. Fukushima replied that Dr. Ito had suggested this a long time ago and this was a good example of cerebellar – frontal cortex interaction.

The next questioner asked if there were identified diseases that impaired upward eye movement in adults. Dr. Fukushima replied that he also tested cerebellar atrophy patients and they had both upward and downward problems. "Was there any sign of morphological maturation in the pre-frontal area for age 11? Were there likely to be other experimental models?" Dr. Fukushima replied that they did not have data.

Dr. Hensch said that they had already heard that early in life REM sleep was dominant and he wondered if binocular eye movement during sleep was different. A second question was what happens in a monocular deprived situation in which there is no feedback through that eye. As to REM sleep, Dr. Fukushima replied, they had only tested this in adult cats, and mostly REM sleep movements were conjugate movements. As to monocular deprivation: he did not know the answer.

The next question concerned patients diagnosed with schizophrenia – who also showed such a disturbance. Had Dr. Fukushima tried to use a flashlight on the targets with such subjects. This improved performance. Dr. Fukushima said that his wife had tested such subjects for an anti-saccade task and half of the patients showed problems with such a task. And with smooth pursuit, again, performance was low. Patients with frontal eye field lesions also had problems. He had not tested using a flash light but had used sound with children, to increase attention, but had found no significant improvement.

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Daniel Wolpert (Institute of Neurology, U.K.)
Motor skill learning

Sensory and motor uncertainty form a fundamental constraint on human motor control. I will first describe how signal-dependent noise on the motor output places constraints on performance. Given these constraints, features of goal-directed movement arise from a model in which the statistics of our actions are optimised. I will then describe how predicting the consequences of our actions can be used to reduce uncertainty, and present experiments on tickling which elucidate this predictive mechanism. Finally, I will present experiments on interference between motor learning tasks, which shed light on the way motor skills are represented in motor working memory.

Dr. Werker opened the questioning by asking if there were adaptation with tickling as existed, for example, with wearing prisms. Dr. Wolpert replied that there was.

Emile Servan-Schreiber said that he had been intrigued by the connection made by Dr. Wolpert between motor action and social interaction and asked if he could discuss "learning to predict oneself". Dr. Wolpert replied that the underlying assumption was that if a person knew his own goals and how they were transferred into action. He could use this process, to understand another person. Stage 2 was: could he use this process to "extract" the goals of another person? How could he learn not just to imitate him but to understand his goals? And stage 3 was based upon the question: "Did the first person have to represent the second person separately from his own system?". These questions therefore touched upon theory of mind: the first person could not use his own states and beliefs to understand the second person, because as two individuals they had different states. It was not possible for one person to use his own current states and beliefs: it was necessary to generate novel entities specialized to the understanding of the second person.

a five year old, given an experimental task, would take as long to unlearn that task as to learn it

Jarl Bengtsson, referring back to Dr. Fukushima's presentation, asked about age differences. Dr. Wolpert replied that it was known infants and children had much more noise than adults. They had much more variability in their system. For example, infants tended to move their eyes towards a target in multiple steps. This again was connected with variability: if they moved their eyes directly to a target, "they would be hunting around all the time". Adults have a very good model of their normal behaviour, but a five year old, given an experimental task, would take as long to unlearn that task as to learn it; whereas adults adjusted back very quickly.

Dr. Uylings then asked about the difference between emotional and non-emotional states. Dr. Wolpert replied that in their work they had not reached a situation to understand this. But basic to their view was the idea that we contained thousands of predictors, tuned for different situations, which we used to predict our own motor behaviours in comparison with those of another person.

Schizophrenics are also equally ticklish if they tickle themselves or are tickled by someone else

The final questioner asked about modeling states for handicapped people. Dr. Wolpert replied they used these models to try to speculate about psychological disorders. For example schizophrenics have delusions of control. They sometimes believe, for example, their arms are being controlled by someone else. One theory is that the sensory cancellation model can be used to decide if the movement is "mine or not". A schizophrenic loses the ability to predict who is causing the movement of his own arm. Schizophrenics are also equally ticklish if they tickle themselves or are tickled by someone else, suggesting a loss of cancellation feedback.

Manfred Spitzer (left), University of .Ulm, Germany, presentation made by Bruno della Chiesa , OECD/CERI, France

The physics and physiology of music

Music is determined, to a large extent, by the physics of vibrating bodies and the physiology of the human auditory system. In order to support this thesis, two experientially different and neurobiologically distant aspects of music are discussed: (1) the implications of limited resolution Fourier analysis of frequencies, which happens at the early stage of listening to music, and (2) the emotional evaluative processes, which supposedly occur at a later stage of musical analysis. Consonance and dissonance can be accounted for by the critical bandwidth of hearing two pure tones (characterized by sine waves), whereas the emotional effects of music are the result of increased activity in the brain's reward system as well as decreased activity in the brain's processing centers for fear and anxiety. Although music has been a part of human culture for at least 50,000 years, and is found in every population studied so far, little hard data are known as regards the function of music in learning and well-being over a life-time. I propose that the time is ripe to perform investigations concerning music, using the methods of cognitive neuroscience.

Denis Ralph congratulated Bruno della Chiesa on his ability to rise to the occasion of representing Manfred Spitzer's ideas and asked him about the ability of the brain to perform under duress, to perform in extremis. Bruno della Chiesa turned the question around to make an anecdotal observation about language.

someone who normally conducted his life in two languages if asked later about a conversation, might recall the details, but not necessarily remember the language in which he had the conversation

His own first language was French. To give Manfred Spitzer's presentation he had needed to read one of Dr. Spitzer's books in German (Bruno della Chiesa's second language), but he tended to manage all matters connected with the LLLN in English – the language of the network. But he had learned English late – when "the plasticity of [his] brain was not that high". He thought that someone who normally conducted his life in two languages if asked later about a conversation, might recall the details, but not necessarily remember the language in which he had the conversation. But he thought when it came to speaking about the conversation, such a parallel language user would find, in his experience, that it was easier to use one language rather than another.

Reijo Laukkanen (National Board of Education, Finland) and Emile Servan-Schreiber (OECD/CERI, France)

Science and education dialogue

Reijo Laukkanen opened the dialogue session by saying that the meeting was about life long learning and this was the case for him in listening to the presentations.

Human beings are really "systems – where everything affects everything".

The meeting brought messages to several groups including parents, but some of these messages were "too early" to be implemented. Scientists and researchers wanted to know the advice they gave was good advice. "Education" had also been interpreted very broadly for the meeting, but everything was very relevant. He as an educational policy maker was very aware that policy was usually discussed within the context of formal, school education and not life long learning. He also now better understood that in talking about brain function "everything was connected to everything". Human beings were really "systems – where everything affects everything". With regard to Dr. Uylings' presentation: he had touched on perhaps the most important topic for educators: how does the environment affect learning? In hearing the presentation his understanding was that development of neurotransmitter networks occurred up to the age of 15 years [see synopsis, Dr. Uylings' presentation: "neurochemical/transmitter development runs further into puberty until about 15 years". Also his remarks in the presentation that neurotransmitter networks continue being developed as late as 18-20 years.]. If something was not completed educationally before this stage "have we lost something". Did it also mean that after 15 – the final age of compulsory education in some OECD countries – there were different teaching conditions? What were the implications of the science to curriculum planning? How was it possible to balance different curricula for different ages? As to Dr. Fukushima's presentation: this was the first time he was aware of such research. He thought the research applicable to education if one thought of the lack of concentration of certain students. For example, math teachers very often complained that students failed because of poor concentration: they were incapable of careful reading of questions. The research might also be of particular interest for special education development. Dr. Wolpert's research might also be applied to special education. Vocational education would certainly benefit from the experimental approaches described – for example in the acquisition of three-dimensional imaging skills.

Emile Servan–Schreiber then introduced himself. As a cognitive psychologist by training he was surprised that he had to wait until his third year at college, until the age of 20, before he learned how the brain worked. He believed that the LLLN project was two sided:

1 about improving teaching practice;
2 about improving learning practice.

Improving learning practice was relevant to people of all ages. It was not about "us giving fish to people, but about teaching them how to fish". The greatest barrier to learning was the fear of learning something new. Having the right model about how the brain works, would contribute greatly to improving learning practice. It had been frustrating to hear researchers come close to "crossing the bridge" to education – particularly when discussing language. He suggested that a good strategy for proceeding with the network would be for researchers to imagine that, by some miracle, they had been made education minister and to imagine what kind of change they would like to impact on the policy side. As to educational policymakers: a good strategy for them would be to imagine that – again by some miracle – they had been provided with a neuroscientific research team: what kind of research would they carry out?

Denis Ralph remarked that teachers were aware of the serious problems they were facing, and this sometimes made them early adopters and adapters of new ideas. Teachers were enthusiastic about neuroscience, but when he met them much of what they based their teaching ideas upon was "neurobabble". How can we ensure teachers get the right information based on sound research?

Dr. Uylings, in reply, briefly discussed the difficulty of balancing evidence from twin and other studies, to making a decision on the relative effects of environment and genetic factors. If he were asked to draw up a curriculum in light of this evidence, he could not. And while brain science was important, we had learned from history not to draw conclusions too quickly from data. Developmental stages varied from individual to individual. There were also significant differences between the sexes. As to Reijo Laukkanen's question about neurotransmitter network development and education: research was just at the beginning, although he had been interested in Dr. Hensch's discussion of critical periods. But learning did not stop at the point at which the brain was mature; there were optimal ages for certain sorts of learning – notably language learning. Novelty and reward were also important; but that was common sense, and known by teachers. Educational material could not be boring.

Dr. Cheour pointed out that in Finland parents had themselves started day care facilities and schools for children. Adults viewed education differently. Children saw it as fun and interesting. It did not represent an end to their childhood. However, children in Finland normally began to learn a language at the age of about 9.

Emile Servan-Schreiber then asked why teachers were so eager to jump on new ideas. Perhaps the research being carried out was not relevant to their problems. The educational community should be providing the research community with relevant questions.

Denis Ralph replied that he was concerned that many of the popular "brain-based education" books were not accurate. Teachers were enthusiastic; when his centre had offered brain science related courses to teachers, they had always been oversubscribed.

Jarl Bengtsson then recalled that Emile Servan-Schreiber – who had been involved in the OECD project from the beginning – had always been interested in the notion of an individually adapted tool box for learning: adapted that is in terms of the learner's own brain. He wanted to ask researchers if such a tool kit idea had been developed. And if it had not; would it be possible to develop such a thing?

Dr. Uylings replied that psychotherapy was interesting in this way, but good research had taken more than 20 years. And it was not fully effective. But there was no body of work in education, based on brain science, using strict hypotheses. The solution was twofold: 1) it was necessary to examine critical terminological differences such as those in the study of learning and memory in animal and human models, and 2) there should be rigorous testing of educational hypotheses. The direction in which to proceed started with "good, testable hypotheses".

In discussing the notion of a bridge between education and neuroscience, Bruno della Chiesa cited the 1997 article by John T. Bruer[3], to say that it was necessary for both sides to take a few risks to begin the crossing. A simple idea – already suggested – was to have two sorts of intervention for questions: the first scientific and the second educational. He also wondered how many of the neuroscientists attending the meeting, would have attended if at least 10 minutes of each presentation had to be devoted to education: meaning human education. We were not interested in educational policy for rodents. He also discussed the difficulty of dealing with the media and compared the situation of a neuroscientist or other expert being asked to appear on prime-time news, being like asking Albert Einstein to explain the theory of relativity in 15 seconds.

Dr. Werker said that she would like to add to the dialogue the fact that education began a long time before children went to school. Her own research was trying to address the fact that children were not all ready to begin the same things in the same way. She liked the idea of a toolbox but school systems were not designed to work with individuals. Schools were designed to rank people.

Emile Servan-Schreiber replied that the toolbox idea was designed for individual learners. It was not an idea that needed to pass through the school system. He then asked Dr. Cheour if her sleep research [see above: " Our recent results demonstrate . . . that human newborns can learn to discriminate difficult speech-sound contrasts . . . while they are sleeping."] was ready to "sign into practice". But she replied that more research was needed.

Bernard Hugonnier then observed that the list of 10 questions in the book earlier published by the OECD[4] were not being properly addressed and without trying to answer them the gap between education and science would

3 John T. Bruer, Education and the brain: a bridge too far", Educational Researcher, 26:8, November 1997

4 Understanding the brain, towards a new learning science. OECD, 2002

be unbridgeable. [the questions are:

1 What is the balance between nature and nurture in the promotion of successful learning?
2 How important are the early years to successful lifelong learning?
3 How significant is the distinction between "natural development" and "cultural education"?
4 If the distinction is significant, how can we best promote these two types of learning – "natural development" and "cultural education"?
5 How far is the successful learning of specific attitudes, skills and knowledge age-related?
6 Why is remedial education so difficult?
7 What can be said about different "styles of learning"?
8 What is intelligence?
9 What is emotional intelligence?
10 How does motivation work?]

Jarl Bengtsson concluded the dialogue by saying that researchers should be familiar with these questions because they represented the main concerns facing educators today.

END OF SESSION II

Session III: learning across life

Jellemer Jolles (left), University of Maastricht, Netherlands.
Neurocognitive function in a life span perspective: relative contribution of biological and environmental influences.

There is a differential decline of neurocognitive function with age. The speed of information processing declines already in the fourth decade of life. This applies especially for those cognitive processes which are dependent upon areas and circuits within the prefrontal cortex. Thus, the so called 'executive functions' are among the first to deteriorate with age, and this may become manifest as a decrease in the efficiency of processing of new information, increased forgetting, lack of attention and concentration and decreased learning potential. These findings have been done in the Maastricht Aging Study (MAAS) which involves a cross sectional and longitudinal study involving 1840 healthy subjects aged 25 through 85, who receive extensive follow-up every three years. Both structural and functional brain imaging is performed in subgroups of these subjects in order to evaluate the above thesis. It indeed turns out that differential neurocognitive patterns can be discerned in healthy aging subjects and that areas in the prefrontal cortex are *implied in this process. Experimental interventions with respect to executive functioning in healthy middle-aged and old subjects by 'Goal Management Training' reveal that trajectories can be changed into more 'successful' aging. Similar findings have been done in the Study of Attentional Disorders Maastricht (SAM), involving 1000 children aged 5-10 who are followed up with similar indices of prefrontal functioning. The results indicate that cognitive neuroscience can contribute to 'learning science' and with respect to finding avenues for better performance and quality of life in children, adolescents and adults.*

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The first question concerned the measurement of variability in the data presented: the point being that data related to older subjects tended to inter-individual variability. Dr. Jolles replied that he was concerned with such variables as health, education, social background, and so on. So if subjects were controlled for these factors, in setting up the study, then inter-individual variability was "much less".

> ***for the better educated and those with "financial resources" there is not so much change related to memory and cognitive ability with age.***

Dr. Ito then asked if there were any factors that improved with age. Dr. Jolles indicated that it was important to remember that the data shown represented the mean of a larger population. But he was convinced that for the better educated and those with "financial resources" there was not so much change with age. Changes related to memory and higher cognitive function, in better- educated people, occurred much later. Experience, wisdom, "the over-view of a situation" were all important. And the pre-frontal cortex was important as an overseer of long-term memory and experience. In people in their forties, fifties and sixties this overseer function was better than in younger people. But as one got older so health factors sometimes intervened and the wisdom that one might have as an older person was compromised by health problems.

Jarl Bengtsson congratulated Dr. Jolles on his presentation and thought it a study that would be useful for many ministers of education to hear. He had two questions:

1 With regard to the sample of 1840 people: was this group broken down by ethnic group or culture?
2 Following on from Dr. Ito's question: do you have any plans to research factors that may improve with age?

Dr. Jolles replied that the group wholly comprised people of Caucasian origin. As to the second question: they were also working on "incidental learning" – which improved with age – but the data were not yet available. But it was an interesting research area. Working with groups of different ethnic origin was also of importance for the future.

Dr. Werker said that she had recently met a biopsychologist, Martin Sarter, who studied development of the acetylcholine system. [Professor Martin Sarter, Department of Psychology, Ohio State University]. He had raised the possibility that those who select to work in education or fields that require abstract thinking may have "different brains to begin with". Dr. Jolles replied that this was a form of the nature-nurture debate, but there is research that suggests it might be "the other direction". Studies show that environmental factors – nurture – are important for the expression of genetic information and that the contribution of nurturing is larger than that for genetic factors. "I am sure there may be something in what you say", but the nurture factor may be more important in other cases.

Bernard Hugonnier said that he had been interested by discussion of the effects of pesticides and chemical products. It may be possible to believe that since most children live in cities and cities are increasingly polluted, then long-term brain performance may decrease. Was this a view Dr. Jolles would support? And in the surveys you have done have you compared [cognitive] performance in the countryside versus that in cities? Dr. Jolles replied that in the data he had referred to about pesticides: those exposed (farmers) had been living in the countryside. The area for our study includes both countryside and town, so we plan to compare people. But studies, for example, of cadmium exposure in children in cities suggested worst performance on cognitive tests, across socio-economic background. So "yes, pollution is something we should look at".

Studies, for example, of cadmium exposure in children in cities suggested worst performance on cognitive tests, across socio-economic background. So "yes, pollution is something we should look at".

Hideaki Koizumi (left), Advanced Research Lab., Hitachi Ltd.

Functional re-organization in damaged, aged brains.

Functional reorganization in damaged older brains is a significant issue related to the rehabilitation of higher-order brain functions. It is also important in increasing our understanding of brain plasticity and functional connectivity. The reorganization of the functional areas for somato-m otor, language, and pre-frontal association will be studied by applying advanced non-invasive brain-functional analysis methods, such as fNIRS (functional near infrared spectroscopy like optical topography), fMRI (functional magnetic resonance imaging), and TMS (trans-cranial magnetic stimulation). The plasticity of older brains will also be compared with younger brains. The critical period of functional reorganization after brain injury will be investigated from the viewpoint of molecular biology. This investigation will give us a comprehensive concept of plasticity including that in the pre-neonatal stage.

The trend of an aging population and decreasing birth rate is progressing rapidly, especially in developed countries. This study will contribute to further understanding of problems, such as dementia, associated with an aging population and assist in improving QOL (quality of life) for the senior generation.

In this meeting we will present the scope of our research plan and some preliminary results such as the observation (through longitudinal studies) of functional reorganization of damaged older brains.

Dr. Jolles asked if the method described were restricted in use to cortical areas. Yes, but if one thinks of the differences, for example, between chimpanzees and humans the difference is very much attributable to cortical areas. That's why we developed this kind of optical method. But the method can be used with babies and neonates, because they can move around. This is not the case with fMRI. We have already measured laterality of the language area in neonates. Dr. Jolles replied that it was attractive to have the mobility aspect of the method, but still thought it important to combine structural imaging and functional data. Dr. Koizumi agreed and said, for this reason, they were trying to combine the method with ultrasonic for babies, since ultrasonic was very safe. But fMRI is possibly "too much" for neonates.

Given the flexibility and mobility of optical topography, asked Bruno della Chiesa, is there any reason to continue using fMRI in the study of the cortex.

Will optical topography soon replace all other methods? Dr. Koizumi replied that the weak point of the optical method was spatial resolution. Temporal and spatial resolution are both important and the same process is performed many times as part of brain observation, but the brain itself “is not static”. So very high temporal resolution is necessary for the observation of real brain function. X-rays, for example, have very high spatial resolution, but [are not useful for observation] of the heart, for example, because it is always moving. Brain function like heart function is always moving and changing. So temporal resolution is the key to observing real brain function.

MEG, the optical method, utilizes photons with energy of less than one electron Volt, so this kind of photon would not destroy human tissue.

Dr. Cheour: I agree fMRI is a lot more harmful for infants, but MEG is not harmful according to studies. She asked about the safety of the optical method. Dr. Koizumi agreed that MEG was a “nice method” and then replied that the optical method they used utilized photons with energy of less than one electron Volt. And the chemical bonding energy of tissues is more than one electron Volt. So this kind of photon would not destroy human tissue. In the case of ultra-violet light, this destroys tissue and causes burning because the energy is several electron Volts.

The next questioner asked if the optical method could be used with deeper areas of the cortex, for example the insula [located within the cerebral cortex and associated with visceral function and integration of that part of the nervous system that regulates involuntary action]. Dr. Koizumi replied that sometimes they had difficulty observing such deep areas of the cortex, they were able to obtain a good signal from the acoustic area and parts of the visual cortex, but they had not tried with deeper areas of pre-frontal cortex, and would like to try to do it. The second question was: how expensive was it to use the optical device when compared to fMRI which was very expensive. In principle, replied Dr. Koizumi, it should, as a semi-conductor device, be very cheap. At present it was being used as a diagnostic tool in medicine and was very large, but it costs about one-fifth of fMRI.

Stanley Colcombe for Arthur F. Kramer (U. Illinois, U.S.A.)

Neurocognitive decline in older adults: descriptions and interventions

cardiovascular fitness provides a powerful mechanism to reduce both structural and functional decline in the aging brain

We will review briefly some historical background on models and concepts of neurocognitive aging, and then turn to more recent developments in neurocognitive approaches to understanding the aging brain.

Our research relevant to the OECD project is largely based on an integration of the historical and current perspectives to both understand the nature of cognitive *decline in older adults, and to develop interventional approaches that may help to minimize or ameliorate these declines. We will review several of these research projects, including an examination of the neurofunctional signatures of older adults who show relatively little decline in* *executive cognitive functioning, the effects of cardiovascular fitness on the structural and functional integrity of the older adult central nervous system, and the effects of cognitive training on neural recruitment in an older adult population. Briefly summarized, the results of our research endeavors in this area suggest that cognitive training can be beneficial to basic cognitive function in older adults, and that cardiovascular fitness provides a powerful mechanism to reduce both structural and functional decline in the aging brain.*

Dr. Uylings asked if the high physical fitness and high mental fitness groups were correlated. "We controlled for socio-economic status, health status – in terms of hypertension, alcohol and caffeine consumption …" While there was no task specific correlation, one of the basic predictions of the research, Dr. Colcombe stated, was a correlation between physical and mental fitness. The data presented, Dr. Uylings replied, did not specify the ages studied. Dr. Colcombe replied that they were adults aged 55-79. It was a relatively high age group. Dr. Uylings: "What was this group compared to?". Dr. Colcombe replied that there was no comparison: it was a "continuous metric of age", and a general linear model does not require a comparative group. Dr. Uylings justified his approach by pointing to the existence of "huge, inter-individual variability in aging". It was more usual, he believed, when researching morphometry to use groups that took this inter-individual variability into account.

Dr. Werker then asked about the controls used: In the hormone replacement therapy studies had they controlled for socio-economic status and education? Dr. Colcombe replied they had found no correlation between them. Was that because variability within the group was so reduced? Dr. Colcombe replied that would be his guess. Other studies tended to be positively correlated. But the group was so tightly packed "along those dimensions, there had been little systematic variability".

Bruno della Chiesa (OECD/CERI, France) and Geoff Masters (Australian Council for Educational Research)

Science and education dialogue.

Bruno della Chiesa introduced Prof. Masters and asked him, "as a newcomer" for his thoughts on the meeting.

We will be living in a society that will be increasingly older and a society that will see an explosion of knowledge. So educators needed to think about what they could do to prepare people to operate in such a world

Prof. Masters introduced himself as an educator. As such he was interested in identifying what we know with confidence about education that can be passed to policy-makers and practitioners to "improve learning outcomes". He remarked that education was sometimes thought of as an industry, or as being formal schooling. But his focus as an educator was learning in the wider sense. Whether this meant learning in early childhood or throughout the lifespan. Within education "learning" meant the development of knowledge, the development of skills and sometimes attitudes and skills, that we identify as important. Because of changing demographics, we also needed to be particularly interested in the topic covered in the morning session: learning in aging populations. Within the next few decades in Australia, for example, there will be an explosion in the numbers of people in their 70s, 80s and 90s. So maintenance of cognitive function in aging populations, how we might slow decline, assist in recovery of function, were important. We will be living in a society that will be increasingly older and a society that will see an explosion of knowledge. So educators needed to think about what they could do to prepare people to operate in such a world.

Many people within the education community have, Prof. Masters continued, tended to see the brain "as a black box". The line of thinking of educators was: "there is nothing we can do about biology and genetics" but "we can change the contexts in which learning takes place, we can change opportunities for learning, the kinds of experiences that we give people" and try in this way to improve learning outcomes. As a community, educators have also developed a belief that "what any one person can learn . . . everybody else can learn given the right time and conditions". This was really more a matter of faith rather than solid, scientific evidence. Prof. Masters then showed the audience a copy of a book that was of influence among educators he knew: "How people learn"[5]. The book raises questions about whether research findings in education and psychology should be linked to neuroscience. One of the findings is that experts in particular domains possess knowledge that is highly structured. Structured around key ideas, principles or concepts. Such structuring allows experts to recognize meaningful patterns of information and is important to learning. It is very important, therefore, that teachers recognize that learners, children or older people, are constantly engaged in this structuring process. Another important concept was that people should monitor their own learning. The "whole concept of meta-cognition, being aware of oneself as a learner, is thought important, but he wondered what support there was for this in brain science. He was unsure himself of what sort of questions it was reasonable to ask of the scientific community. What he was interested in was research-based information that he could take back to policy makers and practitioners.

5 How people learn: brain, mind, experience and school, John D. Bransford , Anne L. Brown and Rodney Cocking, editors, Washington: National Academy Press, 1999.

Bruno della Chiesa thanked Prof. Masters then remarked that dialogue between the two areas, education and brain science, was difficult for a number of reasons, but brain science“is basically a descriptive. . . discipline”.

Brain researchers are basically interested in describing realty. Educators are basically interested in intervention

Brain researchers are basically interested in describing realty. Educators are basically interested in intervention. What can brain scientists say that Prof. Masters can take back to practitioners and others?

Dr. Jolles discussed the structuring of knowledge: knowledge on the one hand and processing on the other: both for children and adults we can clarify how to use knowledge as well as possible. This is certainly true for children 4-10 and for those 13-20. Children don’t know how to use the knowledge they have. With computer assisted learning, for example: computers have to be fed rules. People have different strategies for knowledge processing, liguistic, for example, or visual. Let us make these strategies explicit. This would be a good interface for learning and brain sciences.

Bruno della Chiesa said he had a very specific question following on from something Dr. Jolles had said earlier about education protecting against decline. “Does this have to do with density of synapses?” The second question was related to reduction of synaptic density: did this lead to onset of decline? Was decline thus related to primary, secondary and tertiary education: did the benefits of this remain for the whole of life? Or was it that the more educated one was the more intellectually challenging life was likely to be? So the challenge and not the earlier education kept one cognitively fit?

Dr. Jolles said it was a very nice question and Bruno della Chiesa had interpreted correctly in listening to his talk earlier. Dr. Jolles did think that education gave rise to increase in and efficiency of “relations between cells - more spines (8-10,000 per cell) - better efficiency of transmission.” When there are more spines, there are more to spare. Education acts, therefore, to give you more resources. Language teaching in an abstract sense – words to describe sensations and feelings, for example, represented knowing. Knowing requires words and words requires learning. That was a major problem in our society: the “zapping society”: “zapping from TV channel to TV channel”. Both children and adults have insufficient time to go deeper into more abstract words.

Knowing requires words and words requires learning

Dr. Ito raised a second way of looking at the problem. The first was to load the brain at an early stage of life. But "brain capacity is limited – if you fill up [the brain] at an early stage of life then there is no room . . . later".

brain capacity is limited – if you fill up [the brain] at an early stage of life then there is no room . . . later

He quoted a Japanese proverb: "great talent grows very slowly". Children who are geniuses later become mediocre people. This latter hypothesis is grounded in the hypothesis of a psychological module system, according to which the brain has a limited number of modules. It is not of limitless capacity. This is an important issue and one has to be careful about it.

Bruno della Chiesa recalled a remark of Montaigne: "Il veut meilleur avoir une tete bien fait qu' un tete bien plein": "it is better to have your head well organized rather than full".

Emile Servan-Schreiber then asked Dr. Ito what he meant by brain capacity being limited. Was there evidence suggesting that it was possible to cram only so many skills into one brain? Dr. Ito replied that again this was a very vague hypothesis, but the cerebral cortex has about 100,000 columns [a column, that is, of functionally similar neurons: the size of a macro-column is about 0.4-1.0 mm across]. It represented enormous functional capacity, but was still limited. Furthermore, in the human cerebellum – which is divided into micro-zones rather than columns – there are only 5000 such units.

Dr. Hensch remarked that one piece of evidence in support of Dr. Ito's proposal comes from bi-lingual speakers. Recent imaging studies indicate that people who learn two languages before the age of twelve use the same area of cortex, but those who learn after 12 use multiple areas. The latter situation is possibly less efficient. This sort of information may lead to the development of new learning strategies. We may need to think of new ways of training adults [learning languages] to activate the same area. Perhaps this is not even possible. It may only be possible during the so-called "critical period". These kind of data would be interesting for future education.

According to Manfred Spitzer, Bruno della Chiesa remarked, owls just after birth, use vision to adapt the auditory systems for location of prey. If fitted with polarized glasses with a 15 degree shift, the owls cannot properly locate prey. When the glasses are removed the owls compensate and correct for the shift. When re-fitted with glasses later in life the birds again adapt. This re-discovery of a silent system may be compared to the situation with language learners who do not use a particular language for a long while, then -when in a situation where it is used - re-discover the skill in a short time. Is it possible to have an educational

language learners who do not practice a particular language for a long while, can re-discover the skill in a short time when in a situation where this language is used.

technique to enable re-discovery of silent skills?

it is possible to "pick up tricks" to train the adult brain

The research referred to by Dr. Spitzer, was, Dr. Hensch explained, carried out by Eric Knudsen [Prof. Eric Knudsen: Department of Biology, Stanford], and "the story has become much more interesting in the past few months". The work is on the tectum of the barn owl. Dr. Hensch said, when he spoke about it in Japanese he used the phrase "mitsugo-no-tamashi": " the spirit of the three year old". We all remember, for some reason, even in old age, what we learned when we were three years old. This is a clear example of "circuits that are etched into the brain" that even though dormant can be re-activated under the same environmental conditions. What you did not make clear in describing the owl study, he explained, is that if the owls are given different goggles – with different visual alteration – then they cannot adapt because they are beyond their critical period for learning. The exciting part is: in September [Prof. Knudsen] published a paper using untrained adult birds and goggles of extreme shift; perhaps 25% proved too extreme. But, he reported, some adult birds could adapt as well as young birds if glasses of incremental shift - 5 degrees, 5 degrees and so on - were used. It does show, if one understands the young developmental process, it is possible to "pick up tricks" to train the adult brain. In the experiment, Prof. Knudsen used no pharmacological intervention: it was "just an incremental training paradigm". A final point: the reason why multiple maps can exist in these birds is growth of new synapses". These are inhibitory synapses: so if there are multiple maps in the brain, then the map that is relevant must inhibit the other maps. In adults the inactive map is inhibited by GABAergic connections.

With reference to metacognition: Denis Ralph gave an account of a programme in Australia called "learning to learn". This required that teachers and students be aware of metacognition. So from an early age children had a "window" on their own learning. This benefited both children and teachers who were motivated by a clearer view of the learning process. In those schools that were part of the "learning to learn" programme morale among teachers was also higher.

With reference to the book, "How people learn" [see above]. A major contributor to the book, present at an earlier meeting organised by RIKEN Brain Science Institute, was Dr. Rodney Cocking; who had recently died. And Denis Ralph wanted to acknowledge Dr. Cocking's contribution to education.

Bruno della Chiesa added that Rod [Cocking] was one of the first people to support the OECD/CERI project from the beginning.

Janet Werker addressed her first remark to Takao Hensch: there was imaging data to suggest that an expert second language user did use the same brain areas as with his or her first language - even if the second language were learned later in life. Therefore "the story isn't over yet with respect to brain imaging" of language learning expertise. Dr. Werker then referred to data she herself had collected while still a graduate student: these related to subjects in Vancouver with exposure to Hindi in the first two years of life. For some reason this exposure had stopped around the age of two. As adults these subjects were more likely to achieve better results on Hindi sound tests. Generally speaking the challenge for learning was to know when to allow exposure to a language and how to time inhibition of [unwanted categories] as learning progressed.

She then went on to share an anecdote with the meeting. On first visiting Japan she was "struck by the years and years of training that people will go through to achieve high levels of expertise". That did not occur in North America: people wanted to master things instantly. Possibly we miss something in that rush for instant mastery. Perhaps we need all those 5 degree changes like the Knudsen barn owls. The gist of the story was that she had returned to taking piano lessons - after 20 years: in playing the piano in the intervening period her hand positions had become poor. Her level of expertise in the pieces she could play was low. In taking lessons again she was playing much simpler pieces. And focusing on tiny changes in hand position.

Bruno della Chiesa then suggested, with regard to learning and timing, that this was an area in which brain research may contribute to education. One of the main problems for students was that everything was organised around examinations and cramming for examinations. Was this what we wanted? Could we organise our examination system better to reward slower, surer learning? Bruno della Chiesa then said that he had stopped playing the piano at 7, because he had a younger brother of 5, who was much better. Thus he had lost both motivation and pleasure in music. But he said he would start again.

With regard to examinations: Prof. Masters said he thought if examinations were of the [learn and forget] type then they were not focussed on real learning. Examinations needed to tap into deep understanding of concepts.

A further problem, Bruno della Chiesa said, was that in France, for example, students were not allowed to take any sort of information with them into an examination. What situation in life is like that? Imagine being asked to solve a problem at work without free recourse to necessary information.

Dr. Cheour added that it was very unusual for anyone in real life to ask a question to which the answer was: a, b, c or d. She was disappointed that American universities, in particular, did this rather than asking people to write essays giving their own opinions. As to language processing: that the processing should occur in the same areas was a sign of expertise. Expertise also meant that one tended to use fewer areas of the brain rather than more. As to "training" people to learn a language: with infants this was a matter of maintaining an ability they already had. And not all languages were equally difficult or easy with respect to the same features: sounds close to those of our own native language archetypes were more difficult to discriminate later in life.

Dr. Koizumi said he considered motivation the most important aspect of learning. For example: Dr. Werker's motivation for taking lessons again was connected with the fact, he knew, that she had just received a new piano. Loss of motivation was common in education these days. From a brain science point of view, cultivation of motivation was very important.

> ***From a brain science point of view, cultivation of motivation is very important***

Bruno della Chiesa believed that if one person was able to learn something then "probably everybody, as Prof. Masters had indicated, is able to learn the same thing". Not within the same time frame, or in the same way. He would like the brain researchers to comment on this since motivation is related to pleasure. Providing pleasure to learn is there. is everything learnable?

Dr. Uylings rephrased the question to ask: "Can anybody become an Einstein?" The implication is that everybody is able to master higher mathematics, for example.

Prof. Masters acknowledged that at each end of the range of achievable learned skills there were one or two exceptions. But those who supported the idea would say that for 95% of the population, things were learnable given the right conditions and motivation and so on.

> ***for 95% of the population, skills were learnable given the right conditions and motivation***

Bruno della Chiesa replied that as far as he was concerned there was nothing against the idea that most people can learn things given the right motivation and opportunity. Was he correct in thinking this?

Dr. Cheour said that for adults language learning was difficult, but not that much more difficult than for younger people.

END OF SESSION III

Takao Hensch , BSI, Japan: chair
Future strategy meeting

Dr. Hensch reminded the meeting that its purpose was "the creation of a new way of thinking. Perhaps because we are at the beginning, there is a sense of frustration on both sides of the divide. The answers are not there yet.". He then listed five points for attention:

1 Clarification of complexity,
2 Dissemination of information,
3 Research collaboration,

4 The development and ethical supervision of novel research,
5 Logistical management of 1) to 4) above, with commitment to a second meeting in the early part of December 2003.

Clarification of complexity: many terms such as "learning" or "critical period" were being used at different levels. For someone studying plasticity at a synaptic level "learning" did not mean the same thing as it did for someone teaching in the classroom. "Critical period" was another such phrase. But each brain function has a critical period and higher cognitive functions are a combination of such critical periods. So we need to break these issues down into discrete parts. Thousands of such words were "thrown about casually" but needed rigorous definition. There was also much information out in the field; in education, for example, where teaching in the classroom might be regarded as experiments in training young brains. Basic brain researchers are often not in touch with this information. Even within neuroscience there are large databases that rarely "intermesh". For example cognitive psychology has a long history of dealing with concepts and principles that often shares terms with cellular neuroscience. But neuroscientists are dealing with specific cellular/molecular events - so there is confusion. Even for neuroscientists it would be good to link these large pieces of information. Everyone knows of the problem, but we need to take practical measures to solve it. Who is going to collect this information? What are the terms that we really need to define? Can we come up with a lexicon of key terminology? Before opening up the topic for further discussion Dr. Hensch introduced Dr. Michael Miller from (BSI, Japan) who would write the report on the meeting.

Professor Lenz said that he would first like to comment on discussion of complexity: in Europe, he explained, there was no single use of the term "lifelong learning": perhaps a glossary of terms reflecting these cultural differences would be a useful approach.

Dr. Uylings added that in the clinical sciences there were consensus conferences: this would apply to a clinical, scientific topic like "dementia": what it was, what we could do about it and so on. We could do this for topics at our own meetings.

Dr. Werker asked if it were possible to agree these terms at a broad level then go on to specify how they were utilised within a particular field of study. She did not think agreement of such global terms would be too difficult. The nuances of use would be important. How they were used and if they were used "responsibly".

interaction with information science - robotics - brought in a lot of new terms and concepts

Dr. Ito observed that brain science had been interacting with other fields of research for several decades. Firstly with clinical medicine, and twenty years ago terms from clinical medicine including those from psychiatry were unfamiliar. Now neuroscientists were familiar with these terms and concepts. Again interaction with information science - robotics - brought in a lot of new terms. Education seems to be tough because it is a new field, but he had found - in the open lecture two days earlier - many members of the audience had been familiar with terms such as "critical period". So brain science concepts were spreading and it just needed a little more effort to facilitate their acceptance. He did not consider the gap too great. Perhaps on the educational side there should be more effort to spread understanding of terminology.

Bernard Hugonnier thought what was being suggested was the right approach. Links also needed making with psychologists. Policy makers, in particular, had been drawing much of their information from psychological work. He also asked if we should ask further questions: what are the main issues as far as lifelong learning is concerned? What are the main challenges for educators and policy makers? The OECD had some expertise in this area and knew the main questions.

Dr. Shunichi Amari reminded the meeting that when talking of agreed meanings for certain terms, such as "critical period" there exist many different mechanisms and key differences in their involvement as to age and task.

Emile Servan-Schreiber said that, as a psychologist, he thought most problems with a lexicon would come about in combining the "vocabulary of psychology with that of neurobiology". For example: "short term memory" in psychology means a few seconds while in neurobiology it denotes a few hours or days. But combining education and neurobiology will probably be easier. "Plasticity" means nothing in education and "intelligence" means nothing in neurobiology. So it should be "pretty easy".

Dr. Ito said that in brain science when we referred to learning we generally used the psychological definition. Any experienced- based change of behaviour was termed "learning". In education, "learning" signified the acquirement of some new knowledge.

Professor Lenz suggested that the way forward with lexicology may be not to close gaps between disciplines, but to reveal differences and contradictions and then to move on.

the way forward with "lexicology" may be not to close gaps between disciplines, but to reveal differences and contradictions and then to move on.

Dr Werker thought this a good idea. She also indicated that terms were use differently not just between disciplines, but within a discipline. For example: "habituation" was used differently by researchers within psychology. At one level it meant "a decline in responsiveness" and at another it meant dishabituation within a given domain of behaviour. But beginning the dialogue on terms was important.

Dr. Hensch agreed that confronting complexity was important. Perhaps the best way of proceeding was to ask educators to provide a list of terms they thought needed defining.

Jarl Bengtsson made two points: firstly, a transdisciplinary approach to research was extremely important. If one looked at research and development in OECD countries, most of it was in the private sector: about 70%. This private sector research was largely transdisciplinary research. Secondly, someone mentioned John Bruer's, book, "Education and the brain: a bridge too far", and Bruer's view was: the bridge would be difficult to cross without "capitalising" on the discipline of cognitive psychology. It is important, therefore, that cognitive psychologists are involved in the network.

Dr. Hensch said he was not familiar with the book "How people learn . . ." [see above] which had already been referred to in the meeting and he wondered how much research already existed, that identified key concepts in learning.

Bruno della Chiesa reported that the network had a difficult experience with this in Granada two years earlier: one practitioner at that meeting had produced a book - representing his view of the importance of neuroscience to education - but the reaction from researchers was "quite explosive", and they had decided at that stage it was "a bridge too far".

Professor Lenz wanted to refer to Professor Spitzer's new book [title not given] which was available in German and in preparation in English. Professor Lenz and Bruno della Chiesa both thought the book very valuable.

Dissemination of information:

In opening the discussion, Dr. Hensch referred to network members' obligation to produce a publication after three years explaining what educators and neuroscientists had learned from each other. A lexicon would be a start. For basic researchers it was equally important to publish review articles related to this research; especially if it involved experimental work.

One idea was to persuade a major science journal to dedicate a special issue to it. Such an approach would increase researcher's motivation and have a bigger impact on the debate. A second idea was a web site incorporating a tool box. A place where anyone can go and get information. Something that is updated often and based on the latest research. "We then have to consider what is a reliable result in terms of research". A third issue is dealing with the mass media. We have all experienced this: we have a finding, which is captured in a news item or grossly exaggerated as to its importance. What is the best way to combat this? One idea was that we should collaborate with an information provider such as NHK [Nippon Hoso Kyokai: Japanese national television]. Have them follow us and describe what we are doing. All of these suggestions are geared towards reaching the widest audience possible, in as many OECD countries as possible, and outside the OECD. Perhaps the service we can provide is a demonstration of the difficulty of this bridge-building; rather than a quick result. In discussion of point 5 , “Logistical management”, I am going to ask you when you think this can be done. We all think it a good idea someone should do it, but how can we do it? Perhaps I can ask Emile for his views, since he has been thinking about the web site, I know.

Emile Servan-Schreiber replied that the plan for the OECD web site was to have something established by summer 2003; possibly by July. The material to be included was still not agreed. The idea was to update the site as the network meetings proceeded. The OECD would be relying on researchers to update news of work going on in the networks. Not only in the form of published papers, but possibly pre-prints or lab reports. The idea being to turn these into something readable for the general public and policy makers. He wanted to stress that the OECD could not wait for researchers to publish results in review journals. This might be a problem and we need to discuss this. Obviously we need information within the next two years. We can have people look into your labs, interview you about progress and the sorts of questions you are addressing. At the same time we do not want to interfere with your ability to publish in professional journals.

Janet Werker replied that she was "trying to be sympathetic". Firstly, the idea of even contributing to an OECD report made her feel unhappy because she felt she could only write so much a year. Additional writing impacted research. "You need an OECD report, we need peer-review articles." Secondly, she did not mind discussing work in progress, but did not want it entered into any kind of permanent archive until it passed through peer-review.

> ***The OECD is basically interested in practical applications of research results***

Bruno della Chiesa replied: "Do not worry!" The OECD had learned that the only way of proceeding with such a project was "not to bother the scientists" with anything not directly linked to research. Scientists will not be asked to write anything directly for the publication planned for 2005. Since the OECD is basically interested in practical applications of research results, we would not be interested in taking scientific research as such and publishing it on the web site. There is both a "digesting process" and a "feedback mechanism" involved in this dissemination of information. "In my opinion, there is no risk there." We might. from time to time, send an interviewer to you, a science writer, but we won't bother you in your research. "Nothing more than that."

Denis Ralph raised again the subject of the book, "How people learn . . ." with respect to the OECD web site as a means of disseminating information about brain science and learning. In Australia, the book had been used in many school districts. And in the USA a book had been published of teachers' responses to "How people learn . . .". Members of the present meeting might like to look at that follow-up report in addition to the original volume.

> ***Perhaps the OECD should create a day for learning around the world***

Masao Ito then described the role of "World Brain Awareness Week": it is held in March each year. At BSI about fifty high schoo l students were usually invited to see what is going on in the institute. However, we found that teachers wanted to join the project: they did not want to be less knowledgeable than their pupils. "So last year we invited only teachers." The aim is to teach people how modern neuroscience proceeds. Perhaps the OECD should create a day for learning around the world.

Professor Lenz remarked that as a member of a traditional European university he believed in research and lecturing: "if we want to create a new field we have to create a new student body". Why don't we establish an international summer school? Why don't we think about an e-learning course?

Dr. Tanaka said he found review articles written by scientists too difficult for the general public, whereas such articles written by professional science writers tended to be very good. Perhaps we should ask a high school teacher to spend a sabbatical year, travelling around the world, interviewing neuroscientists in order to write about their work.

Dr. Hensch agreed with the idea of a science writer and put the suggestion back to Emile Servan-Schreiber. It sounded as if the site would be up and running soon, but he appreciated Janet Werker's honest response. We are all busy and facing a lot of competition. And science writers were usually better at the job of disseminating information about research. A possibility might be to have interviewers coming around in order to have the information put on the website for educators at all levels. Questions arising might be posted on the website. A large part of the problem is that there is interest, but we don't know what questions need to be asked.

Bruno della Chiesa replied that this was exactly what they had in mind. As to Dr. Ito's suggestion: an early idea had been to organize a world brain forum, the time was not ripe for this, but he personally kept the idea very much in mind. Perhaps that might be a phase three project.

Janet Werker recalled the work of the Orton Dyslexia Society [now the International Dyslexia Association: see details above with website address]: they publish a journal, have meetings including scientists, educators and parents of teachers with reading difficulties. So the models for co-operation do exist.

Takao Hensch reminded the meeting that BSI had been running a summer program for a number of years, and the topic for 2003 was "nurturing the brain". This was the first time that the topic was so "all encompassing", so it would be interesting to see who would come. Dr. Hensch raised again the topic of publicity and controlling the output of information from the network.

Emile Servan-Schreiber suggested that the science writers employed by the network might be involved in this to the extent that information from the networks might be published in scientific journals providing sufficient space to explain complexity and "not betray the work that is being done".

Dr. Hensch then asked if the OECD were interested in developing tools, computer games or learning materials, for example, or were they reliant upon others doing this?

the idea is to have tools developed by scientists on a web site: diagnosis and remediation tools, for example

Bruno della Chiesa replied that the idea was not only to disseminate information and have feedback, but also to have tools developed by scientists on the web site: diagnosis and remediation tools, for example. The literacy network intends to do something like that for dyslexia as soon as the web site is operational. I do not know if this network can produce tools of that kind.

Dr. Hensch then asked how familiar the media were with the fact that the OECD was doing this kind of research. Can links be made so that when issues of brain science and learning arise, members of the media first turn to the OECD for information?

Jarl Bengtsson replied that he thought the OECD was doing quite a good job at the moment. The book published earlier by the OECD, "Understanding the brain . . ." (see footnote 4) was already being noticed.

The book, Bruno della Chiesa added, was released in September [2002] in both French and English. The German translation is finished, the Spanish translation is due at the end of December [2002], the Japanese translation is under way, we are discussing Chinese, Russian, Korean, Polish, Italian is already underway, Portuguese and so on. We were happy that our publications department reacted to the book immediately. The book was mainly going into OECD languages, aside from Chinese and Russian, but he would be pleased to have a copy into Arabic too. As a model for future publications it was a good one.

Bernard Hugonnier added they had other resources for providing the mass media with information: the first was policy briefs: these were widely distributed in the world in French and English. It was the intention to have one of these on brain research. There was also a magazine, “The OECD Observer”: it was the intention to have one or two articles in this magazine in the following year. There was also a forum organized at the same time as the ministerial meeting in May or June. In the last forum we had a meeting on brain science and it was the most successful and well attended.

Bruno della Chiesa confirmed the success of the forum and said he was now discussing a follow-up for the forum in 2003.

Following a suggestion by Janet Werker that there be some formal contact with schools on explaining brain science, Bruno della Chiesa, reminded the meeting that those who could explain research interestingly, such as good science writers, were difficult to find. If both scientists and educators identified a person as being good at explaining such matters then "we have certainly found the right person". Approval of one community is not enough. Whoever we recruit must be approved by both sides.

Dr. Vouloumanos said she wanted to highlight the importance of the web site. Many of the parents whom they encountered in their child studies asked about basic matters connected with language acquisition and neuroscience. Parents are also the very first “intervention”. One cannot overestimate the importance of the web site as a disseminator of information.

Parents are also the very first “intervention”. One cannot overestimate the importance of the web site as a disseminator of information [to parents]

Dr. Hensch said all these suggestions were useful and the science writer idea needed acting upon immediately. We would like the information up on the web site. We would like someone to come round to interview us. He thought it would take perhaps a year for "us to get things together". His own hope was that this network would lead to novel research. With regard to the ten questions listed in the OECD booklet: some were interesting and some, in his opinion, too general. But the web site would provide more imput.

Bruno della Chiesa agreed the ten questions were too broad to be addressed as such, but they believed these questions were very important and thought it part of the responsibility of scientists to look at these questions and use them. We are looking to you to shape answers to these or related questions.

Dr. Hensch then read the ten questions to the meeting as a reminder:

1 What is the balance between nature and nurture in the promotion of successful learning?
2 How important are the early years to successful lifelong learning?
3 How significant is the distinction between “natural development” and “cultural education”?
4 If the distinction is significant, how can we best promote these two types of learning – “natural development” and “cultural education”?
5 How far is the successful learning of specific attitudes, skills and knowledge age-related?
6 Why is remedial education so difficult?
7 What can be said about different “styles of learning”?
8 What is intelligence?
9 What is emotional intelligence?
10 How does motivation work?

Dr. Wolpert asked to comment on the ten questions: he said that for scientists specific questions with yes-no answers were better than grey-scale questions such as "how important is . . .". Such questions were going to be very hard to answer.

Professor Lenz replied that perhaps it was better to regard these as research themes rather than specific research questions. And he would like to add one: "What sort of abilities do self-directed learners need?".

Emile Servan-Schreiber added that, with regard to the nature-nurture discussion, the educational community was often ignorant about the biological bases of learning. Some people still believed that everything is environment – because that was the politically correct attitude. So brain science certainly had a lot to say about this; even if it were "grey".

Dr. Hensch thought such questions could equally well be answered by educators rather brain scientists. If educators and neuroscientists were to answer the same questions on the same website it would be valuable.

Jarl Bengtsson said that if one looked at educational research for answers to these ten questions one could not find clear answers. The reason they were raised in the book [by Sir Christopher Ball] was that perhaps the new discipline of brain science could provide some new insight into what decades of educational R&D had not been able to provide. But it would be useful to have a clear summary for scientists of what educational research did say about certain topics.

Janet Werker said that she had been stimulated to think about the educational aspects of her research and perhaps it was a good idea for scientists to be interviewed soon after this network meeting for their thoughts - rather than later when they were immersed in the details of their scientific work.

Geoffrey Masters commented that educational research had been productive in looking at the early years of childhood. It was established that parents were very important, for example, in the acquisition of reading ability. It was also known that the manipulation of objects was important to acquisition of mathematical skills. It would be interesting to know if these matters could be connected to brain research.

Dr. Hensch recounted his own experience in taking his children to a day care centre in Japan and in not knowing if the method of managing the center in Japan was superior for the children to the way things were managed in other countries. This point was followed by Dr. Uylings who said such a study would be valuable since social interaction in such centres varied greatly from country to country.

Jarl Bengtsson thought this an important discussion: particularly the difficult matter of the social ideologies behind different educational R&D methods. For example the OECD had published a major report on day care: "Starting strong". There was very heavy criticism of the report from the USA; that saw the report as being insufficiently "science based". "Bridges can be made", but we should be aware of the difficulties.

Lifelong learning is not an academic discipline - it's a new approach to "societal demand"

Professor Lenz wanted to clarify the position of education as an academic discipline: pedagogy as a discipline had begun about two hundred years before and then become educational science fifty years ago using more empirical methods - especially in Europe. And about thirty years ago continuing education was established as an academic discipline. Lifelong learning is not an academic discipline - it’s a new approach to "societal demand".

Discussion then turned on collaboration between network members and sharing of databases; with respect to ensuring the quality of data made available. Emile Servan-Schreiber suggested that the setting up of e-mailing lists via OECD might facilitate initial communication between researchers. Dr. Hensch then moved discussion forward to:

<u>Development and ethical supervision of novel research</u>:

Certain issues had been touched upon in the earlier London meeting, but had not properly surfaced here:

1 Ethical considerations: this is applied neuroscience; for the first time and on a large scale. It is probably wise to have some consideration of the ethical issues: for example, it had been asked, "Is it possible to extend the critical period?" That was scientifically fascinating. But what did it really mean for human beings? Another aspect of the same issue is that if one placed too much

emphasis upon a critical period's importance [and timing] then parents may lose hope if they have a child [whose development does not fit the critical period model]. "Hope-giving" was important and we ought to consider it. Any potential policy recommendations may also have implications fifty years from now. In the USA bio-ethics - specifically related to neuroscience - is now a hot topic.

2 Issues such as attention or motivation came up in the London meeting, but are not specifically addressed in our network. Nutrition and brain function was another topic.
- Dr. Uylings injerjected that motivation, nutrition and sleep were all variables taken into account in the study he was involved in. A further topic was development of mind or further cognitive function.

Janet Werker remarked that she had collaborated a little with a bio-chemist looking at the early effects of nutrition. First of all, work on baby formula was "incredibly political" and what could be called by that name was a matter of contention. And the researcher with whom she had co-operated was looking for protocols and tasks. Janet Werker had worked out a modus vivendi with the nutritionist on sharing staff and so on. This was a way of participating in such research without carrying it out in its entirity.

Jarl Bengtsson made two observations: on the ethical issue, this would increase in importance as the network grew. The mass media would be very much interested in the work from that point of view. He also referred to Brian Appleyard's book: "Staying human in the genetic future", which he recommended because of its ethical sensitivity. The second observation was strategic: of the three networks the first two were of particular importance for younger people: this network may have to make a choice between [developmental interests or later in life]. And the political community were expecting a lot from the aging brain side of the work.

Professor Lenz wanted to stress the importance of self-directed learning and the re-training of the brain. There is a "social gap" between trained and untrained learners.

Bruno della Chiesa recounted that when OECD/CERI was considering the networks, the possibility of a fourth (on emotion) was mooted. We did not have the means to run more than three. But we did think emotion ought to be addressed in each of the three. He was personally convinced that motivation was the key to all learning. And he would like each of the players involved in the network to take motivation into account.

Janet Werker remarked that rate of habituation in infancy and preference for novelty both predict IQ up to age 12. This suggests intelligence is given and measurable from birth. However experience with contigent interactions in the laboratory or home suggests it influences both rate of habituation and preference for novelty. This is motivation and relates to lifelong learning. It effects how we proceed throughout life. For reasons like these she liked the fact that this network was embracing lifelong learning: from conception to the end.

Dr. Tanaka pointed out that motivation was not "a single quantity": a group of brain structures was involved. It is not just the hypothalamus that is involved.

motivation is not "a single quantity": a group of brain structures is involved

He also recounted an experiment in which knock-out had been modelled, and such mice were soon de-motivated. So neuroscience was beginning to understand motivation. But there was not much work as yet on development of motivation. So this would be a good focus for the sort of work to be done in this network.

Finally, Dr. Hensch asked: "Who will do this work?" As to clarification of complexity the web site was obviously important. It could be used to start the dialogue. He did not think a clear time frame could be constructed. We have three years. The web site will exist in perhaps six months. Perhaps the first task was recruitment of a scientific writer. We should also hold another meeting - at the end of 2003 or beginning of 2004. How the meeting would be organized would depend on how the web site operated. If it generated lots of questions, perhaps that would be the launching point. Another possibility would be to have a meeting of the same format, but allow educators rather than scientists address the meeting. Any suggestions or comments would be welcome. Is the idea of someone going around the network interviewing do-able?

Bruno della Chiesa asked scientists at the meeting if such a person would need to come around "physically" or was it possible to do part of it electronically?

Dr. Cheour replied that she would prefer to work with someone there. Did it have to be the same person? There was always more room for mistakes if things were done entirely by email.

Dr. Uylings replied the best method was to meet. But another means of carrying out the task would be for each country to invite a science writer known to them to carry out the interviews. This would save on travelling expenses.

Emile Servan-Schreiber, who had worked as a science journalist, remarked that there was nothing to replace someone actually going into the lab. and carrying out the interviews in person. Even though one had to prepare carefully beforehand, by reading the papers and knowing about the work. As to using several people for the task: that was acceptable too. It did not have to be the same, globe-trotting, person. The OECD was thinking of rewarding such writers on an article basis. They were not thinking of a tenured job. So if scientists had names in mind, please inform the OECD.

Dr. Hensch said his own experience had been it was much better to speak to someone. But he thought it better to have a person, who had also spoken to all of the other people: thus giving them a special perspective. If there were many people in many countries they should collaborate on their interview findings.

Janet Werker suggested asking NHK or a similar provider to support the interview work as part of its potential coverage of the research.

Emile Servan-Schreiber reminded the meeting that the web site was intended to promote the idea of the project. This would include publication of open research questions. This would be like brain-storming: collecting ideas from the scientific and educational communities. After related questions, he also promised that OECD/CERI would set up a mailing list for each of the networks early in 2003.
Jarl Bengtsson (OECD/CERI, France), Masao Ito (BSI, Japan), Bernard Hugonnier (OECD/CERI, France) and Masayuki Inoue (MEXT, Japan)

Closing remarks

Jarl Bengtsson offered three observations in closing:

1 It is obviously going to take some time for the dialogue between scientists and educators to yield results. We need patience if we want a “quality product” in three years time.

2 He then mentioned William James work, “Talks to teachers on psychology” [full title: “Talks to teachers on psychology and to students on some of life’s ideals”, 1899] in which James said “psychology is a science and teaching an art”. This is still how we see things in education. I am not against teaching as an art, but perhaps there could be more science. It is interesting to note that spending on R&D in education, as a percentage of total spending on education, is 0.25-30%. There is no other knowledge sector in the modern economy that spends so little on research.

3 We all know that medicine and engineering, for example, have been guided by the Newtonian paradigm: which has had enormous success. We also know of other paradigms such as that represented by quantum physics. Dr. Koizumi, in his talk, brought up the question: “why does the brain have dual functions?”. Perhaps the answer to this question can be approached via a Newtonian or quantum route, but this is a question for you to answer. Thank you and good luck.

Bernard Hugonnier speaking as a representative of the management side recalled that there were three main objectives for the programme and one was to create a new community of interest, involving scientists, educators and policy makers. We have made some useful progress. In attending the meeting he had learned the following:

1 Scientists’ time was limited and neuroscientists were not necessarily interested in applied research. Therefore some sort of interface was needed between basic neuroscience and its potential

applications.

2 A second problem concerned vulgarization of scientific results. The solution being considered was to use scientific writers as a means of communicating potentially useful findings. But we would need to be prudent about what was being said. We must also guard against taking specific, isolated findings and generalizing them into educational policy.

3 It is encouraging to note that scientists too can be made more aware of the potential "pertinence" and usefulness of their work. How was it possible to raise the awareness of all those scientists engaged on similar or related work?

4 On the education side, we should also be more precise about the questions we wish to raise. We need to refine these broad questions.

5 As Jarl Bengtsson had indicated, we must be patient. But policy makers were not patient. They wanted a "silver bullet". There is an urgency about the many problems that exist. It is our job to bring some answers to policy makers.

Bernard Hugonnier then expressed his gratitude to the RIKEN Brain Science Institute, to MEXT and in particular to Drs. Ito and Hensch.

Masao Ito concluded by saying that he would like to add one point: the project was certainly a tremendous challenge for the educational community, but it was also an equally great challenge to brain science. "Brain science" covers a wider field than "neuroscience" because it includes information-type research. It is said that our times are defined by genomic science, and we are facing the "post-genomic" challenges. So people are turning from a reductionist approach, cell to gene, to a reconstructive approach.
People dream of reconstructing cells from genetic blueprints, and more ambitiously, the reproduction of living bodies. Brain science aims higher: it aims at reproducing behaviour and, eventually, the mind. The present project is therefore taking this reconstructive approach. About 60% of present-day neuroscience is based upon highly reduced preparations such as tissue culture, sliced brain tissues or simple animals such as nematode [structurally simple parasitic worm containing about a 1000 somatic cells: see www.nematode.unl.edu for a beguiling, guided tour of its scientific uses and importance]. However, the final goal is to understand what is a human being, and what is mind.

Dr. Ito then thanked the OECD for initiating such an ambitious project and for joining the meeting. He also thanked MEXT, network members, the guest speaker, Dr. Fukushima and all other participants in the project. Finally he thanked members of the BSI staff for organizing the meeting so successfully.

Annex 1

AGENDA OF THE MEETING

	DECEMBER 10TH
09:00-09:30	Masao Ito (BSI, Japan), Bernard Hugonnier (OECD/CERI, France) and Masayuki Inoue (MEXT, Japan) **Opening remarks.**
	Gentaro Taga (U. Tokyo, Japan): chair
Session I:	**Learning in infancy**
09:30-10.00	Janet F. Werker (U. British Columbia, Canada) **Bootstrapping from speech into language: neural and behavioural foundations.**
10:00-10:30	Risto Nätäänen and Marie Cheour (U. Helsinki, Finland) **Speech-sound learning in infants.**
10:30-11:00	Frances Champagne for Michael J. Meaney (McGill U., Canada) **Maternal care, gene expression and brain development: evidence for inter-generational effects.**
11:00-11:30	Takao K. Hensch (BSI, Japan) **Critical period mechanisms for brain development.**
11:30-13:00	Bruno della Chiesa (OECD/CERI, France) and Werner Lenz (U. Graz, Germany): moderators **Science and education dialogue.**
Lunch	
	Keiji Tanaka (BSI, Japan): chair
Session II:	**Learning in childhood**
14:30-15:00	Harry B. M. Uylings (NIBR, Netherlands) **Phases in development and aging of the human cerebral cortex: genetic influences on human cognitive abilities.**
15:00-15:30 Cancelled	John Gabrieli (Stanford U., U.S.A.) **Development of cognitive control and emotion regulation in children.**

15:30-16:00	Kikuro Fukushima (Hokkaido U., Japan) **Role of the frontal cortex in smooth tracking eye movements in three-dimensional space.**
16:00-16:30	Daniel Wolpert (Institute of Neurology, U.K.) **Motor skill learning.**
16:30-17:00	Bruno della Chiesa (OECD/CERI, France) for Manfred Spitzer (U. Ulm, Germany) **The physics and physiology of music.**
17:00-18:30	Reijo Laukkanen (National Board of Education, Finland) and Emile Servan-Schreiber (OECD/CERI, France) **Science and education dialogue.**
Reception	
	DECEMBER 11th
	Yasushi Miyashita (U. Tokyo): chair
Session III:	**Learning across life**
09:30-10:00	Jellemer Jolles (U. Maastricht, Netherlands) **Neurocognitive function in a life span perspective: relative contribution of biological and environmental influences.**
10.00-10:30	Hideaki Koizumi (Hitachi Ltd., Japan) **Functional re-organization in damaged, aged brains.**
10.30-11:00	Stanley Colcombe for Arthur F. Kramer (U. Illinois, U.S.A.) **Neurocognitive decline in older adults: descriptions and interventions.**
11:00-12.30	Geoff Masters (Australian Council for Educational Research Ltd.) and Bruno della Chiesa (OECD/CERI, France): moderators **Science and education dialogue.**
Lunch	
	Takao K. Hensch (BSI, Japan): chair
	Future strategy meeting
14:00-16.30	(All) **Open discussion**
16.30-17:00	Jarl Bengtsson (OECD/CERI, France), Bernard Hugonnier (OECD/CERI, France), Masao Ito (BSI, Japan) **Closing remarks**